Over-Snow Vehicle Sound Level Measurements

Conducted for the Winter Use Plan Supplemental Environmental Impact Statement (SEIS)

for
Yellowstone and
Grand Teton National Parks
and
John D. Rockefeller, Jr.
Memorial Parkway

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Prepared for:

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ABSTRACT / INTRODUCTION:

This study of over-snow vehicle sound levels was conducted to provide new and additional information for preparation of the Winter Use Plan Supplemental Environmental Impact Statement (SEIS) for Yellowstone and Grand Teton National Parks and the John D. Rockefeller, Jr., Memorial Parkway. The pass-by sound level of a variety of over-snow vehicles was measured at operational speeds that would be experienced under normal use of the vehicles while in the national park units. The pass-by testing included four different types of snow coaches and various models of snowmobiles. All testing was conducted on the same day in the same location with the same terrain and background conditions.

This study is intended to supplement a previous study commissioned by the National Park Service entitled “Technical Report on Noise: Winter Use Plan Final Environmental Impact Statement”(1). This report bears the number “HMMH Report No.295860.18”, and was written and submitted by Harris Miller Miller & Hanson, a noise and vibration consulting firm located in Burlington, Massachusetts. Much work in that study concentrated on calculating the threshold of audibility of various vehicle types in various types of terrain and background noise conditions. The sound levels assigned to the various vehicle types were general in nature. This report is not intended to conflict with nor supplant the report indicated above, but rather, may be used to supplement the general information used in the FEIS report with more specific sound data regarding various vehicle types.

Due to time constraints associated with producing the SEIS, it was necessary to perform the sound testing on a grass surface rather than on a snow surface where these over-snow vehicles are normally operated. However, grass is an acceptable substitute under Society of Automotive Engineers (SAE) testing protocol guidelines. Therefore, a testing series was planned and implemented in West Yellowstone, Montana on September 13, 2001. Eighteen different snowmobiles were tested for sound emissions, along with four different types of snow coaches and two common wheeled road vehicles.

The testing for the snowmobiles was conducted at three different operational speeds – 20, 35, and 45 mph. These speeds are reflective of the normal operational speeds in congested areas and permitted speeds while operated on the park snow roads. During the testing, it was discovered most of the snow coaches could not safely reach the higher

target test speeds. Consequently, the snow coaches and conversion vans were tested according to their individual capability. Test speeds for the snow coaches are reported in the results table.

TESTING PARAMETERS:

The Code of Federal Regulations (CFR) addresses the issue of sound emissions from snowmobiles and snowplanes, but does not address sound emissions from snowcoaches. 36 CFR 2.18 Snowmobiles: states, "maximum A-weighted pass-by sound levels at a distance of 50 feet (15.2m) under full throttle shall be a maximum of 78 dB(A) for snowmobiles." 36 CFR 7.21 and 7.22 specify "maximum sound emission levels at 50 feet under full throttle from snowmobiles at 78 dB(A) and from snowplanes at 86 dB(A). The CFR regulations say nothing substantial about how the measurements are to be taken.

Test procedures for the measurement of snowmobile sound emissions have been established by SAE and are outlined by SAE Standard J1161, Mar83. The basic layout for the test track, speed at which the test is to be made, and basic operational considerations for the instrumentation are enumerated in this Standard. This Standard is in conflict with the CFR regulation in that the Standard specifies a speed of 15 mph (24 kph). There is an additional SAE Standard, J-192, which provides for the sound level measurement of snowmobiles while being operated at full throttle. The sound testing for the Clean Snowmobile Challenge 2001 SAE design competition used both standards for the layout and testing of the sound level of the competing snowmobiles under maximum acceleration conditions. The general procedure as described in SAE 2001-01-3652 (2) was used for this testing, with testing being conducted at steady state speeds.

Testing for the snowmobiles was done at speeds of 20, 35, and 45 mph. The 20 mph speed represents speeds likely to be encountered in congested areas, such as around Old Faithful in Yellowstone Park. The 35 mph speed is the speed limit suggested by the State of Wyoming for the road segments from West Yellowstone to Old Faithful. The 45 mph speed is the speed limit on other Park roads. Two skilled and experienced recreational riders drove all of the test runs.

The eighteen snowmobiles tested included one 4-stroke model, a 2001 Arctic Cat 4-stroke, and seventeen different two-stroke models. The two-stroke models tested included one snowmobile with a modified exhaust system (2001 Polaris 800 RMK with a Starting Line Products single pipe) for comparison purposes. All other snowmobiles had stock exhaust systems. All four major snowmobile manufacturers were represented in the testing (Polaris: 7 sleds, Arctic Cat: 4 sleds, Ski Doo: 4 sleds, Yamaha: 3 sleds). It should be noted that the only four-stroke model that was available at the time of testing (due to time constraints of the SEIS process) was the 2001 Arctic Cat 4-stroke prototype. While both Arctic Cat and Polaris have 2002 production four-stroke models available, neither had come off the production line at the time of this testing.

The four snow coaches tested included two conversion vans (one Ford equipped with front skis and a rear track and one Chevy equipped with Mattracks), a Prinoth articulated snow coach, and a Bombardier with rear exhaust. None of the snow coaches had working speedometers, so an observer inside the coach equipped with a GPS determined coach speeds. This particular GPS, a Garman GPS III, had been checked with police traffic radar for accuracy.

In addition, full throttle acceleration tests were done with two snowmobiles. The Arctic Cat Four-Stroke was tested along with a Polaris Sport Touring machine. The Polaris was the control sled used during the CSC 2001 competition. The Polaris had a peak average reading of 78 dB(A) during this testing as well as during the CSC 2001 testing, indicating a close correlation between the testing on snow and the current testing on a grass surface. The two road vehicles were tested under the same conditions.

The test track was set up at the old airport site just outside of West Yellowstone, Montana. The test track dimensions were pursuant to SAE J1161 for a bi-directional test site layout. The surface of the old airport runway was sparse grass over dirt. The surface was not ideal, but the testing correlated closely with the control sled data gathered during the CSC 2001.

SUMMARY OF PROCEDURES:

1. Test track layout and instrumentation as described in SAE J1161 and J-192.

2. Three runs in each direction were done at each listed speed; the dBA level reported in the results table is the average of the three runs.
3. A total of 416 separate sound level measurements were taken over the course of the testing.
4. Full throttle testing of the control snowmobile showed close correlation with the CSC 2001 test conditions.

TEST RESULTS AND CONDITIONS:

Testing was done on September 13, 2001 at the old airport in West Yellowstone, Montana. A test track was prepared according to SAE J1161 and J-192. The day started out ideal for testing. Skies were partly cloudy. The temperature was in the range of 52ºF to 75ºF. Winds during testing were calm to about 10 mph. The surface surrounding the track was sparse grass covering dirt. The test area was level and free of any trees. The elevation of the test site was 6740 feet above sea level from GPS data. Uncorrected barometric pressure was 23.61 inches Hg by GPS, and the relative humidity was 70% to 80%. A cold front with thunderstorm moved through the area in the late afternoon. Testing was suspended until after the storm passed.

The instrument used for the testing was a Quest Technologies M2100, #DAA070020. The instrument was allowed to equilibrate to ambient temperature for the time it took to set up the test course. The instrument was calibrated using the calibrator supplied with the instrument, with appropriate corrections for ambient conditions. The calibration was checked each hour.

The instrument was set up 50 feet (15.2m) from the track centerline. The instrument was oriented horizontally, with the microphone set 60 inches (1.52m) above the surface. The windshield was in place. Background noise was between 34 to 42 dBA. The testing took place between 8:00AM to 7:00PM. Results are presented in the following tables:

SOUND MEASURMENT TABLES:

Tables 1 through 3 display average sound levels measured for the 18 different snowmobiles at the various speeds. Table 4 provides a comparison of the sound levels measured for the Arctic Cat 4-stroke, the

Polaris control sled from the CSC 2001, the sound level winning entry from the CSC 2001, and two SUV's. Table 5 displays average sound levels measured for the four different snowcoaches. Table 6 provides a comparison of stock snowmobile sound level measurements looking at: displacement, mileage, fan cooled, two-stroke, four-stroke and brand. A complete listing of all sound measurements recorded may be found in Appendix I.

Vehicle Type	Make/Mileage	Model	**Year**	**VIN**	**Engine/Track**	**Speed**	Sound Right	Sound Left
Snowmobile with Modified Exhaust	Polaris 388 mi	RMK 800	**'01**	4XASM8BS41C155135	800 Liquid cooled, SLP single pipe, 151x2	20	80.5	**81.9**
						35	80.2	80.5
						45	80.5	80.4
Snowmobile	Polaris 1711 mi	RMK 800	**'00**	4XASR8BS64B874428	800 Liquid cooled, 156x2	20	73.2	72.9
						35	74.3	74.0
						45	77.7	77.0
Snowmobile	Polaris 1902 mi	RMK 700	**'01**	4XASM7ASX1C160030	700 Liquid cooled, 144x2	20	70.9	70.0
						35	76.0	76.1
						45	76.7	76.5
Snowmobile	Polaris 4143 mi	RMK 600	**'01**	4XASR6OSX1C160505	600 Liquid cooled, 136x2	20	69.7	68.6
						35	73.8	**73.2**
						45	76.6	76.6
Snowmobile	Polaris 3591 mi	RMK 500	**'01**	4XASR5ASI1C160679	500 Liquid cooled, 136x1 ½	20	69.4	69.5
						35	74.2	74.6
						45	**75.6**	75.7
Snowmobile (Control sled for CSC 2001)	Polaris 5438 mi	Sport Touring	**'01**	4XASD5B571C161445	550 Fan Cooled, 136x7/8	20	73.7	70.5
						35	77.7	76.9
						45	78.5	77.3

Table 1: Average Pass-By Measurements for Individual Polaris Snowmobiles

Vehicle Type	Make/Mileage	Model	**Year**	**VIN**	**Engine/Track**	**Speed**	Sound Right	Sound Left
Snowmobile	Polaris 4486 mi	Indy Trail	**'99**	4XAEB4ES7XC080768	488 Fan Cooled, 121x7/8	20	70.3	71.2
						35	76.0	75.5
						45	76.9	76.5
Snowmobile	Arctic Cat 483 mi	Mt. Cat	**'01**	4UF01SNW01T129371	800 Liquid cooled, 136x2	20	75.0	72.3
						35	75.4	76.0
						45	77.0	76.7
Snowmobile	Arctic Cat 4071 mi	Four Stroke	**'01**	4UF01NW91T159520	660 Liquid Cooled four cycle, 136x1/2	20	**67.3**	**68.2**
						35	73.8	74.4
						45	76.1	76.3
Snowmobile	Arctic Cat 550 mi	Mt. Cat	**'01**	4UF01SNW21T125192	600 Liquid cooled, 136x2	20	71.7	71.9
						35	**73.3**	**74.6**
						45	75.7	**75.3**
Snowmobile	Arctic Cat 1402 mi	Cougar	**'97**	9706911	550 Liquid Cooled, 136x7/8	20	74.0	71.0
						35	76.9	78.0
						45	78.0	79.6
Snowmobile	Ski-Doo 1652 mi	Summit 700	**'01**	2BPS175641V000027	700 Liquid Cooled, 136x2	20	73.0	73.6
						35	77.4	77.3
						45	79.6	**79.8**

Table 2: Average Pass-By Measurements for Individual Polaris, Arctic Cat and Ski Doo Snowmobiles

Vehicle Type	Make/Mileage	Model	**Year**	**VIN**	**Engine/Track**	**Speed**	Sound Right	Sound Left
Snowmobile	Ski-Doo 535 mi	Summit 600	**'01**	2BPS176101V000206	600 Liquid Cooled, 136x2	20	71.0	70.6
						35	76.8	76.9
						45	77.1	76.6
Snowmobile	Ski-Doo 4185 mi	Touring 500F	**'01**	2BPS180511V000152	500 Fan Cooled, 136x7/8	20	72.4	71.3
						35	77.3	76.7
						45	78.1	78.8
Snowmobile	Ski-Doo 3219 mi	MXZ	**'00**	2BPS1566YV000469	440 Fan Cooled, 121x1/2	20	74.9	**72.4**
						35	76.6	76.0
						45	77.0	75.5
Snowmobile	Yamaha	700 Mt. Max	**'01**	8ED011931	700 Liquid Cooled, 141x2	20	70.8	70.1
						35	75.6	74.1
						45	77.1	77.3
Snowmobile	Yamaha 2252 mi	600 Mt. Max	**'00**	8EJ001205	600 Liquid Cooled, 141x2	20	72.5	70.3
						35	75.2	73.5
						45	77.3	76.3
Snowmobile	Yamaha 1270 mi	600 Mt. Max	**'99**	8CS006586	600 Liquid Cooled, 136x1 ½	20	71.2	69.7
						35	76.0	75.5
						45	76.9	76.5

Table 3: Average Pass-By Measurements for Individual Ski Doo and Yamaha Snowmobiles

Vehicle Type	Make/Mileage	Model	**Year**	**VIN**	**Engine/Track**	**Speed**	Sound Right	Sound Left
Snowmobile	Arctic Cat 4071 mi	Four Stroke	**'01**	4UF01SNW01T129371	660 Liquid Cooled four cycle, 136x1/2	Full Throttle Acceleration J-192	78.3	78.3
Snowmobile (CSC 2001 Control Sled)	Polaris 5438 mi	Sport Touring	**'01**	4XASD5B571C161445	500 Fan Cooled, 136x7/8	Full Throttle Acceleration J-192	78.7	78.0
Snowmobile (CSC 2001 Control Sled)	Polaris 5438 mi	Sport Touring	**'01**	4XASD5B571C161445	550 Fan Cooled, 136x7/8	Full Throttle Acceleration J-192 During CSC 2001	78.0	
Snowmobile Kettering University Entry CSC 2001	Yamaha Chassis	Custom	**N/A**	N/A	659 cc Daihatsu Turbocharged four cycle	Full Throttle Acceleration J-192 During CSC 2001	**72.0**	
Pickup Truck	Dodge	3500	**'01**	1BTMF33611J255429	Cummins Turbo-Diesel	**Acceleration**	74.9	73.3
						35	68.5	68.2
						45	**71.9**	69.6
Sport Utility Vehicle	Chevrolet	Suburban 2500	**'01**	3GNGK26U41G103683	6.0L Gasoline V-8	**Acceleration**	70.1	68.4
						35	62.7	63.1
						45	64.8	64.4

Table 4: Comparison of Average Pass-By and Full Acceleration Measurements for Arctic Cat 4-Stroke, CSC 2001 Polaris Control Sled, CSC 2001 Sound Category Winner and two Trucks

Vehicle Type	Make/Mileage	Model	**Year**	**VIN**	**Engine/Track**	**Speed**	Sound Right	Sound Left
Articulated Tracked Snow Coach	Prinoth	N/A	**N/A**	N/A	5.2L Chrysler V-8 w/auto transmission	21 Measured with GPS Onboard	79.6	80.4
Conversion Van – Front Skis, Rear Track	Ford	E350	**'00**	1FBSS31S9VHA03291	Gasoline V-10 with Auto Transmission	20	73.9	78.0
						25	76.1	**81.3**
						Speed Measured with GPS onboard		
Conversion Van – Four Tracks (Mattrack)	Chevrolet	3500	**'99**	1GAHG39FXX1036234	6.5L Turbo-Diesel w/ Auto Tranmission	20	74.0	74.7
						25	**78.0**	79.0
						Speed Measured with GPS onboard		
Snow Coach	Bombardier	B-12	**'81**	101810085	5.2L Chrysler V-8 Rear Exhaust	20	**69.9**	**71.5**
						25	79.9	**78.0**
						Speed Measured with GPS onboard		

Table 5: Average Pass-By Measurements for Individual Snowcoaches

Stock Snowmobile Sound Levels by Category			
Category	Speed		
Displacement	**20**	**35**	**45**
500 cc or less	71.4	75.8	76.8
501 – 699 cc	71,1	75.6	77.0
700-799 cc	71.4	76.1	77.8
800 cc	73.3	74.9	77.1
Mileage			
0-1000	72.0	75.5	76.4
1000 - 3000	71.6	75.7	77.6
3000 and up	70.7	75.5	76.8
Fan Cooled	72.1	76.6	77.3
All Two Stroke	71.9	75.5	77.3
Four Stroke	67.7	74.1	76.2
Brand			
Polaris	70.8	75.2	76.8
Arctic Cat	71.4	75.3	76.8
Ski-Doo	72.4	76.9	77.8
Yamaha	70.8	75.0	76.9
All	71.4	75.6	77.1

Table 6: Stock Snowmobile Average Sound Level Comparisons

ANALYSIS OF RESULTS:

Table 6 is a summary listing of the average sound levels generated by the snowmobiles during this test series. The results are broken into various categories to answer the following questions: Does engine displacement make a difference in the sound level generated? Do snowmobiles get louder as more miles are put on them? Are fan-cooled snowmobiles quieter or louder than liquid-cooled sleds? Is there a significant difference between the sound levels of two-stroke and four-stroke snowmobiles? and Are there noticeable differences between the four major brands of snowmobiles?

As one may see from Table 6, the sound levels are quite uniform across the board, regardless of the category chosen. Sound levels were generally consistent when comparing displacement categories at the various speeds. While the 800 cc class was slightly louder at 20 mph, it was actually the quietest at 35 mph and as quiet as the other engine sizes at 45 mph. When comparing snowmobiles with few miles of use versus over 3,000 miles of use, the ones with more miles were either quieter or as quiet as the new sleds. Fan cooled machines were only marginally louder than average, regardless of the reputation these machines may have for being significantly louder than the liquid cooled versions.

The Arctic Cat Four-Stroke tested was an early production model, introduced to address the sound and emission concerns being debated. Essentially, Arctic Cat adapted a liquid cooled four-cycle small automobile engine to the snowmobile chassis. This is a similar tactic to that taken by the Kettering University team in the CSC 2001 competition. As a category, the Arctic Cat Four-Stroke was the quietest over-snow vehicle tested. Still, the machine generated a higher sound level at 35 and 45 mph than was expected, considering the experience with the Kettering University machine during the CSC 2001. Observers of the Arctic Cat Four-Stroke runs generally commented the increased noise at 35 and 45 mph was largely mechanical and emanated from the track and the skis, rather than from the engine. This was also generally true of several of the more quiet two-stroke snowmobiles tested.

The HMMH Report conducted for the FEIS tested four snowmobiles during their research. All of these were of 500 cc displacement. Cooling type was not addressed. If the snowmobile data from the HMMH Report is compared to this new data (hereafter referred to as the JHSI Report), there is close if not identical correlation at 20 mph to the 500 cc machines tested for the JHSI Report. As speeds increased, the sound levels measured for the JHSI Report were higher than those stated in the HMMH Report. At 40 mph, the HMMH Report finding was 73.9 dB(A). Using the same type of linear regression model as used in the HMMH Report, the data in the JHSI Report is about 2 dB(A) higher at 40 mph. In essence, the slope of the regression line for the snowmobile data is steeper for the JHSI Report than in the HMMH Report.

Some may argue the testing surface for the JHSI Report was the cause of the louder readings than those measured in the HMMH Report. To address this issue, the Polaris snowmobile used as the control sled during the CSC 2001 competition was run through a maximum acceleration test series just as it was run during the CSC 2001. In both cases the sound level measured, rounded to the nearest integer, was 78 dB(A). While this is not definitive, it does suggest there is close correlation to the data gathered on the snow surface.

Four different types of snowcoaches were tested for the JHSI Report. These are listed in Table 5. Testing for the JHSI Report showed significantly higher sound levels for snowcoaches than those reported in the HMMH Report. Again, correlations at 20 mph using the regression model from the HMMH Report are quite close, at least for the Bombardier. As speeds increased, the variation between the HMMH Report data and

the JHSI Report data became more pronounced. For example, the Bombardier sound level at 30 mph was reported in the HMMH Report at 74.6 dB(A). Data generated during this testing (JHSI) reported an average sound level at 30 mph of 78.9 dB(A). The divergence of the data was greatest when the sound levels for the four-track conversion van are compared. At 30 mph, the HMMH study reported a sound level of 69.7 dB(A). The four-track van tested for the JHSI Report produced a sound level of 78.5 dB(A) at 32 mph. This is a significant difference. The Ford two-track conversion van recorded the loudest sound level of any stock vehicle during its testing. The primary reason for this was the loud "hissing" exhaust sound made during the runs at 25 mph, which was the maximum speed for this snow coach.

The HMMH Report mentions using vehicle speedometers in the snowcoaches for speed determination. None of the snow coaches tested for the JHSI Report had working speedometers, which is why the GPS unit was used to determine actual ground speed.

SUMMARY:

The loudest stock over-snow vehicle was a Ford two-track conversion van, which registered an average peak of 81.3 dB(A). The loudest stock snowmobile was a Ski-Doo Summit 700, which had a peak reading of 79.8 dB(A) at 45 mph. A modified Polaris RMK 800 was the loudest vehicle tested overall, with a peak average reading of 81.9 dB(A).

The quietest over-snow vehicle tested was the Arctic Cat Four-Stroke touring snowmobile at 20 mph. Its lowest average reading at this speed was 67.3 dB(A). Several other snowmobiles were in this range of the high 60's to low 70's at the 20 mph speed. The Bombardier snow coach had a low average reading at 20 mph of 69.9 dB(A), making it the quietest of the snow coaches at this speed.

These data show the sound levels of many late model snowmobiles overlap or are quieter than snow coaches under the same or similar testing conditions. The quietest snowmobile at 20 mph produced less sound than any of the snow coaches at the same speed. None of the over-snow vehicles were as quiet as the wheeled road vehicles tested, although the Dodge diesel pickup was near the lower level of the snowmobile sound envelope.

The Arctic Cat Four-Stroke was subjectively considerably quieter at 20 mph than any other over-snow vehicle. This may be due to the fewer exhaust pulses at a given RPM as well as the clutching engagement tailored to the four-cycle engine. As the testing speed increased for this snowmobile, the mechanical sound of the track and under damped skis overcame the engine sound level. One observation is that this higher level of track and ski noise may be generated because of: 1) the blow molded plastic skis on this particular snowmobile model versus a thinner profile plastic ski which appeared to generate less sound on other models, and 2) more noise and vibration emanating from the track, perhaps due to track tension, lug height, or other factors associated with track

noise . Because of this, the Arctic Cat Four-Stroke was not the quietest snowmobile at speeds of 35 and 45 mph.

The lowest average reading for a snowmobile at 35 mph was the Polaris 600 RMK, with a sound level of 73.2 dB(A). The lowest average reading for a snowmobile at 45 mph was 75.3 dB(A) by the Arctic Cat Mt. Cat 600. Both of these machines are liquid cooled. As an aside, the sound level recorded during normal dinner conversation after the testing was 78 dB(A).

The lowest average reading for a snow coach at a nominal 30 mph is 78.0 dB(A). Both the Chevrolet / Mattrack conversion van and the Bombardier B-12 snow coach recorded these sound levels.

For comparison, the Kettering University entry in the CSC 2001 competition recorded a sound level of 72 dB(A) during the maximum acceleration event. We would expect its sound level during steady state operation to be considerably lower than this.

Quiet snowmobiles already exist, as shown by these data. The technology is improving to make these machines even quieter than they are now. Work will need to be done not only with engine sound levels, but also with the mechanical sound generated by the track and skis, regardless of whether the over-snow vehicle is a snowmobile or a snowcoach. This work is going forward with the Clean Snowmobile Challenge as well as by the various snowmobile manufacturers.

The technology appears to exist to require that over-snow vehicles meet reasonable sound regulations. However, any regulations written should reasonably consider that over-snow vehicle sound levels are not attributable just to engine sounds but also must factor in the other mechanical sounds associated with tracked vehicles. Additionally, any arguments for banning snowmobiles because of excessive noise will be based upon emotional rather than scientific reasons since under the excessive sound level argument, snowcoaches would have to be banned as well because they are noisier than snowmobiles.

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Alpen Guides – Bombardier snowcoach
Amfac Parks & Resorts/Yellowstone National Park Lodges – Prinoth snowcoach
Flagg Ranch Resort – 4-track/Mattrack Conversion Van
Polaris West – Polaris snowmobiles
Three Bear Lodge – Front Skis/Rear Track Conversion Van
Wyoming Trails Program – SUV’s and snowmobiles

Yellowstone Adventures – Ski Doo snowmobiles
Yellowstone Arctic-Yamaha – Arctic Cat and Yamaha snowmobiles

We would also like to thank the test riders, Kelly Wells and Ben Adams, for their tireless and invaluable assistance in conducting the 416 sound level measurements for this study.

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4. Society of Automotive Engineers, “Exterior Sound Level for Snowmobiles – Recommended Practice”, SAE J192, March 1985.

5. Society of Automotive Engineers, “Operational Sound Level Measurement Procedure for Snow Vehicles”, SAE J1161, March 1983.

Appendix 1

Raw Data Tables

Vehicle Type	Make/Mileage	**Model**	**Year**	**VIN**	**Engine/Track**	*Speed*	*Sound Right*			*Sound Left*		
Snowmobile with Modified Exhaust	Polaris 388 mi	RMK 800	'01	4XASM8BS41C155135	800 Liquid cooled, SLP single pipe, 151x2	20	80.4	79.6	81.6	**83.5**	**79.1**	**83.1**
						35	79.3	80.6	80.6	80.3	79.9	81.4
						45	78.9	81.3	81.8	79.3	81.8	80.0
Snowmobile	Polaris 1711 mi	RMK 800	'00	4XASR8BS64B874428	800 Liquid cooled, 156x2	20	73.1	73.7	72.9	72.7	73.5	72.7
						35	74.3	74.3	74.3	74.3	73.7	74.0
						45	78.4	77.4	77.4	76.5	77.2	77.3
Snowmobile	Polaris 1902 mi	RMK 700	'01	4XASM7ASX1C160030	700 Liquid Cooled, 144x2	20	70.3	71.2	71.1	70.4	69.4	70.3
						35	76.0	75.2	76.8	75.3	76.6	76.3
						45	77.1	77.0	76.1	76.6	76.6	76.2
Snowmobile	Polaris 4143 mi	RMK 600	'01	4XASR6OSX1C160505	600 Liquid Cooled, 136x2	20	69.9	69.4	69.9	68.5	68.9	68.3
						35	73.8	73.8	73.7	**73.2**	**73.2**	**73.2**
						45	76.5	76.9	76.4	77.2	75.6	76.9
Snowmobile	Polaris 3591 mi	RMK 500	'01	4XASR5ASI1C160679	500 Liquid Cooled, 136x1 1/2	20	68.4	70.0	69.7	70.3	69.1	69.1
						35	74.2	74.2	74.2	73.6	75.8	74.4
						45	**74.7**	**76.3**	**75.8**	75.7	75.3	76.1
Snowmobile (Control sled for CSC 2001)	Polaris 5438 mi	Sport Touring	'01	4XASD5B571C161445	550 Fan Cooled, 136x7/8	20	75.0	74.0	72.0	69.6	70.7	71.3
						35	77.0	78.3	77.7	77.6	76.4	76.8
						45	80.1	77.5	77.8	77.2	77.0	77.6

Vehicle Type	Make/Mileage	**Model**	**Year**	**VIN**	**Engine/Track**	*Speed*	*Sound Right*			*Sound Left*		
Snowmobile	Polaris 4486 mi	Indy Trail	‘99	4XAEB4ES7XC080768	488 Fan Cooled, 121x7/8	20	70.6	70.1	70.1	69.2	69.9	70.9
						35	77.0	78.3	77.7	77.6	76.4	76.8
						45	80.1	77.5	77.8	77.2	77.0	77.6
Snowmobile	Arctic Cat 483 mi	Mt. Cat	‘01	4UF01SNW01T129371	800 Liquid cooled, 136x2	20	75.1	75.3	74.6	73.3	72.2	71.3
						35	75.5	74.9	75.7	76.2	75.7	76.1
						45	76.8	76.8	77.5	76.5	77.0	76.6
Snowmobile	Arctic Cat 4071 mi	Four Stroke	‘01	4UF01SNW91T159520	660 Liquid Cooled four cycle, 136x1/2	20	**66.4**	**67.6**	**68.0**	**68.6**	**68.2**	**67.8**
						35	74.3	73.4	73.6	72.9	75.2	75.0
						45	76.3	76.6	75.4	76.4	77.3	75.3
Snowmobile	Arctic Cat 550 mi	Mt. Cat	‘01	4UF01SNW21T125192	600 Liquid Cooled, 136x2	20	70.4	71.7	73.1	71.3	72.1	72.3
						35	**73.0**	**73.2**	**73.6**	75.5	73.9	74.3
						45	75.7	75.2	76.2	**75.4**	**75.2**	**75.4**
Snowmobile	Arctic Cat 1402 mi	Cougar	‘97	9706911	550 Liquid Cooled, 136x7/8	20	74.4	73.6	74.4	70.2	71.1	71.9
						35	76.7	77.3	76.8	78.1	78.1	77.9
						45	77.5	77.6	79.0	79.7	79.7	79.4
Snowmobile	Ski-Doo 1651 mi	Summit 700	‘01	2BPS175641V000027	700 Liquid Cooled, 136x2	20	71.1	73.2	74.9	72.8	72.5	75.4
						35	78.1	77.7	76.4	77.6	77.5	76.7
						45	79.4	79.6	79.7	**80.0**	**80.1**	**79.3**

Vehicle Type	Make/Mileage	**Model**	**Year**	**VIN**	**Engine/Track**	*Speed*	*Sound Right*			*Sound Left*		
Snowmobile	Ski-Doo 535 mi	Summit 600	‘01	2BPS176101V000206	600 Liquid Cooled, 136x2	20	70.4	71.3	71.2	70.5	70.9	70.5
						35	75.8	77.6	77.0	76.8	77.6	76.4
						45	76.6	76.7	78.0	75.8	77.3	76.7
Snowmobile	Ski-Doo 4185 mi	Touring 500F	‘01	2BPS180511V000152	500 Fan Cooled, 136x7/8	20	73.1	72.1	72.1	71.6	71.1	71.2
						35	76.8	78.7	76.4	76.9	76.4	76.8
						45	77.0	78.4	78.9	79.0	78.6	78.8
Snowmobile	Ski-Doo 3219 mi	MXZ	‘00	2BPS1566YV000469	440 Fan Cooled, 121x1/2	20	73.0	75.3	76.4	71.9	72.8	72.6
						35	76.7	77.0	76.1	76.3	75.8	76.1
						45	78.2	76.1	76.9	75.0	75.6	75.8
Snowmobile	Yamaha 1512 mi	700 Mt. Max	‘01	8ED011931	700 Liquid Cooled, 141x2	20	70.4	71.3	70.8	70.3	69.6	70.4
						35	75.6	75.4	75.9	74.6	74.1	73.7
						45	78.3	76.4	76.7	76.8	77.7	77.3
Snowmobile	Yamaha 2252 mi	600 Mt. Max	‘00	8EJ001205	600 Liquid Cooled, 141x2	20	70.6	72.5	74.3	69.1	71.1	70.8
						35	74.8	75.8	75.0	72.8	74.5	73.2
						45	77.2	76.4	78.4	76.0	76.5	76.4
Snowmobile	Yamaha 1270 mi	600 Mt. Max	‘99	8CS006586	600 Liquid Cooled, 136x1 1/2	20	71.8	70.9	71.1	69.4	69.8	69.8
						35	75.5	75.8	76.9	75.3	75.6	75.6
						45	77.6	77.2	76.0	76.4	76.8	76.3

Vehicle Type	Make/Mileage	**Model**	**Year**	**VIN**	**Engine/ Track**	Speed	Sound Right			Sound Left		
Snowmobile	Arctic Cat 4071 mi	Four Stroke	‘01	4UF01SNW01T129371	660 Liquid Cooled four cycle, 136x1/2	Full Throttle Acceleration J-192	78.2	79.1	77.6	79.0	78.3	77.6
Snowmobile (CSC 2001 Control Sled)	Polaris 5438 mi	Sport Touring	‘01	4XASD5B571C161445	550 Fan Cooled, 136x7/8	Full Throttle Acceleration J-192	78.7	78.4	78.9	77.6	78.4	78.0
Snowmobile (CSC 2001 Control Sled)	Polaris 5438 mi	Sport Touring	‘01	4XASD5B571C161445	550 Fan Cooled, 136x7/8	Full Throttle Acceleration J-192 During CSC 2001	78.0					
Snowmobile Kettering University Entry CSC 2001	Yamaha Chassis	Custom	N/A	N/A	659 cc Daihatsu Turbocharged four cycle	Full Throttle Acceleration J-192 During CSC 2001	**72.0**					
Pickup Truck	Dodge	3500	‘01	1BTMF33611J255429	Cummins Turbo-Diesel	**Acceleration**	74.2	74.7	75.8	73.3	73.6	72.9
						35	67.4	68.5	69.5	66.5	69.6	68.4
						45	**71.1**	**73.3**	**71.3**	69.5	70.6	68.8
Sport Utility Vehicle	Chevrolet	Suburban 2500	‘01	3GNGK26U41G103683	6.0L Gasoline V-8	**Acceleration**	69.4	70.2	70.6	68.6	68.3	68.4
						35	62.5	62.8	62,7	61.1	61.5	66.6
						45	65.0	64.8	64.6	63.6	63.5	66.0

Vehicle Type	Make/Mileage	**Model**	**Year**	**VIN**	**Engine/Track**	*Speed*	Sound Right			Sound Left		
Articulated Tracked Snow Coach	Prinoth	N/A	N/A	N/A	5.2L Chrysler V-8 w/auto transmission	21 Measured with GPS Onboard	80.1	79.0	79.7	80.2	80.7	80.3
Conversion Van - Front Skis, Rear Track	Ford	E350	'00	1FBSS31S9VHA03291	Gasoline V-10 with Auto Transmission	20	73.2	74.6	73.8	73.5	71.1	71.2
						25	**77.4**	**76.1**	**74.8**	**80.6**	**81.7**	**81.5**
						Speed Measured with GPS onboard						
Conversion Van – Four Tracks (Mattrack)	Chevrolet	3500	'99	1GAHG39FXX1036234	6.5L Turbo-Diesel w/ Auto Transmission	22	74.9	73.8	73.2	75.8	73.8	74.4
						32	77.5	78.2	78.5	79.8	79.0	78.4
						Speed Measured with GPS onboard						
Snow Coach	Bombardier	B-12	'81	101810085	5.2L Chrysler V-8 Rear Exhaust	**20**	**70.1**	**69.8**	**69.8**	**71.4**	**70.4**	**72.7**
						30	**82.1**	**76.8**	**80.9**	**76.4**	**76.2**	**81.3**
						25	**73.7**			**74.2**		
						Speed Measured with GPS onboard						